Appendix P

Field Working Agreement between Department of the Interior, Bureau of Reclamation, and Department of the Army, Corps of Engineers for Flood Control Operation of Hoover Dam and Lake Mead

Appendix P

Field Working Agreement
between
Department of the Interior, Bureau of Reclamation
and
Department of the Army, Corps of Engineers
for
Flood Control Operation
of
Hoover Dam and Lake Mead
Colorado River
Nevada-Arizona

February 8, 1984

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
630 Sansome Street, Room 1216
San Francisco, California 94111

REPLY TO
ATTENTION OF:

March ~~15, 1984~~

Engineering Division

Mr. N. W. Plummer
Regional Director
U.S. Department of Interior
Bureau of Reclamation
Lower Colorado Regional Office
P. O. Box 427
Boulder City, Nevada 89005

Dear Mr. Plummer:

A copy of the signed Field Working Agreement for Hoover Dam and Lake Mead is enclosed for your use. I am currently finalizing processing of the agreement as specified in paragraph 208.11 (d) (11) of 33 CFR 208.11.

If you have any questions on this action, please contact Mr. Frank Krhoun of my staff at FTS 556-6210.

Sincerely,

A. E. Wanket
Chief, Engineering Division

Enclosure

FIELD WORKING AGREEMENT

BETWEEN

DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION

AND

DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS

FOR

FLOOD CONTROL OPERATION

OF

HOOVER DAM AND LAKE MEAD, COLORADO RIVER, NEVADA - ARIZONA

This field working agreement, made and entered into this 8th day of February 1984, between the Lower Colorado Region, Bureau of Reclamation and the South Pacific Division, Corps of Engineers,

WITNESSETH THAT:

WHEREAS, Hoover Dam and Lake Mead, Colorado River, Clark County, Nevada and Mohave County, Arizona, was authorized as part of the Boulder Canyon Project Act (Public Law 70-642). The Boulder Canyon Project Act states that Boulder Dam (Public Law 43 changed the name of the structure from Boulder Dam to Hoover Dam) and the reservoir that it creates shall be used: first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses; and third, for power.

WHEREAS, the Department of the Interior, acting through the Bureau of Reclamation, represented by the appropriate Regional Director, hereinafter referred to as the Regional Director, has constructed Hoover Dam and

Reservoir, and is responsible for the safety of the structure and for normal operations of the Lower Colorado River, of which said dam and reservoir are a part.

WHEREAS, the Department of the Army, acting through the Corps of Engineers, represented by its appropriate District and Division Engineers, is responsible for the flood control operation of Hoover Dam and Lake Mead in accordance with Section 7 of the 1944 Flood Control Act (Section 7, Public Law 78-534, 58 Stat. 890, 33 U.S.C. 709), which directs the Army to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds, and as promulgated in the Code of Federal Regulations, Title 33, Part 208.11, 13 October 1978.

WHEREAS, there is a need for a working agreement to insure a clear understanding of flood control regulations and information exchange required for the operation of Hoover Dam and Lake Mead.

NOW, THEREFORE, it is mutually understood and agreed by and between the parties hereto that this field working agreement shall consummate the provisions of the 1944 Flood Control Act for Hoover Dam and Lake Mead. In addition to the responsibilities of the project owner and the Corps of Engineers spelled out in paragraph 208.11, 33 CFR, it is agreed that Hoover Dam and Lake Mead will be operated in the interest of flood control in accordance with the following water control plan.

(a) In order to provide storage space for control of floods, releases from Lake Mead shall be scheduled so that available storage space for flood control will not be less than that indicated in the following table for the dates shown. Flood control storage space shall be the available storage space below elevation 1,229 feet.

Date	Available flood control storage space (acre-feet)
1 August	1,500,000
1 September	2,270,000
1 October	3,040,000
1 November	3,810,000
1 December	4,580,000
1 January	5,350,000

Pertinent information on permissible changes in available flood control storage space in Lake Mead is given in subparagraphs (1), (2), and (3) of this paragraph.

(1) The available flood control storage space in Lake Mead during the period 1 August to 1 January may be reduced to a minimum of 1,500,000 acre-feet, provided the additional space prescribed under paragraph (a) above is available in active storage space in upstream reservoirs. The maximum storage space in upstream reservoirs that can be credited to the 1 September, 1 October, 1 November, 1 December, or 1 January storage space requirement in Lake Mead is given in the following table:

Reservoir	Creditable storage space (Acre-feet)
Lake Powell	3,850,000
Navajo	1,035,900
Blue Mesa	748,500
Flaming Gorge plus Fontenelle	1,507,200

(2) Space building releases from Lake Mead during the period 1 August to 1 January shall not exceed 28,000 cubic feet per second. Space building releases are herein defined as releases for the purpose of attaining the available flood control storage space given in paragraph (a) above.

(3) If, however, available flood control storage space diminishes at any time to less than 1,500,000 acre-feet then the minimum flood control releases are described in paragraph (b) below.

(b) At any time during the year, if available storage space in Lake Mead should become less than 1,500,000 acre-feet, then minimum releases from Lake Mead for flood control shall be determined daily from table 1 (Minimum Flood Control releases from Hoover Dam throughout the year) using available flood control storage space in Lake Mead. Pertinent information on permissible changes in the releases as indicated in table 1 is given in subparagraphs (1), (2), and (3) of this paragraph.

(1) During 1 August to 1 January minimum releases from Lake Mead as given in table 1, if 40,000 cubic feet per second or less, shall not be reduced when once initiated until the storage space prescribed in paragraph (a) above becomes available. During the remainder of the year, releases as given in table 1 if 40,000 cubic feet per second or less are maintained until 1,500,000 acre-feet of storage is available at Lake Mead.

(2) Minimum releases from Lake Mead as given in table 1, if greater than 40,000 cubic feet per second, shall not be reduced, when once initiated, until Lake Mead water surface has receded to elevation 1,221.4 (top of spillway gates raised position). During 1 August to 1 January, releases may then be gradually reduced to 40,000 cubic feet per second and shall be maintained at not less than that rate until the storage space prescribed in paragraph (a) above becomes available. During the remainder of the year releases may also be reduced to 40,000 cubic feet per second upon reaching elevation 1,221.4 in Lake Mead, and shall be maintained at not less than that rate until 1,500,000 acre-feet of storage space is available at Lake Mead.

(3) The releases required in table 1 are minimum releases. Based on forecasted inflow, releases when the Lake Mead water surface elevation is between 1219.61 feet and 1229.00 may be higher during the early stages of a flood so as to achieve a greater reduction in ultimate peak outflow.

(c) Releases from Lake Mead shall be restricted to quantities that will not cause a flow in excess of 40,000 cubic feet per second at the gaging station, Colorado River below Davis Dam, insofar as possible.

However, with the reservoir water surface at the top of the flood control pool, a discharge of about 65,000 cubic feet per second will be passing over the Hoover Dam spillways with the gates in the raised position.

(d) For the period 1 January through 31 July, minimum releases from Lake Mead to attain the 1 August flood control space prescribed in paragraph (a) above shall be determined by use of the Flood Control Algorithm described in Exhibit 1 and Water Loss Equations for Lakes Mead and Powell described in Exhibit 2. Pertinent information on inflow forecasts and on permissible changes in the prescribed releases is given in subparagraphs (1), (2), (3), (4), (5), and (6) of this paragraph.

(1) All inflow forecasts used in carrying out the provisions of these regulations shall be prepared by the Colorado River Forecasting Service located in the National Weather Service River Forecast Center in Salt Lake City, Utah and shall be for the flow of the Colorado River into Lake Mead including the runoff contribution from the tributary drainage area between Lake Powell and Lake Mead.

(2) Lake Mead inflow forecasts as provided by the Colorado River Forecast Service shall be determined from depleted flow. Depletion of natural (virgin) flow shall include transbasin diversions, net water use (diversion minus return flow), and evaporation from reservoirs upstream of Lake Powell. Adjustments to the forecast provided by the Colorado River Forecast Service shall be made for effective storage space in upstream reservoirs as specified in subparagraph (3) of this paragraph. The

maximum forecast for any specified runoff period is defined as the estimated inflow volume (acre-feet) that, on the average, will not be exceeded 19 times out of 20.

(3) Effective storage space in Navajo, Blue Mesa, and Flaming Gorge plus Fontenelle reservoirs is the lesser of the actual space available, or the usable space available. The usable space is the difference between the mean forecasted inflow volume (acre-feet) for any specified runoff period and projected mean reservoir releases. In computing effective storage space for Flaming Gorge plus Fontenelle, the actual space is the sum of the actual available space in both reservoirs; while mean forecasted inflow volume and projected mean reservoir release will be the values at Flaming Gorge reservoir. Effective storage space in a reservoir(s) may be a negative value if projected mean reservoir releases exceed the mean forecasted inflow volume.

(4) When minimum releases for the months of January through July as determined by the Flood Control Algorithm are less than 28,000 cubic feet per second, it will be permissible to release less than the indicated amounts for a part of a month, provided the average releases for the entire month will equal the release given by the Algorithm, without flows exceeding 28,000 cubic feet per second at the gaging station, Colorado River below Davis Dam.

(5) The Flood Control Algorithm described in Exhibit 1 accounts for storage space in Lakes Powell and Mead. Whenever sufficient runoff occurs, Lake Powell is expected to fill to capacity (water surface

elevation 3700.0 feet) and Lake Mead is expected to fill to capacity (water surface elevation 1219.61), and remain full until 1 August so as to preclude any increase in the flood control releases specified by the Flood Control Algorithm above 28,000 cubic feet per second at the gaging station, Colorado River below Davis Dam.

(6) The objective of the Flood Control Algorithm is to specify releases such that Lake Mead will be no higher than water surface elevation 1219.61 feet (1,500,000 acre-feet of available storage space below elevation 1229.0 feet) on 1 August. Subsequent revisions to the minimum releases specified by the Flood Control Algorithm may be made during July if justified by a forecast of the remaining runoff and comparison with empty reservoir space available.

(e) During the period 1 January through 31 July the larger release specified by the Flood Control Algorithm versus table 1 shall be the required minimum release.

(f) At anytime of the year, Hoover Dam releases shall not result in a flow rate greater than 28,000 cubic feet per second at the gaging station, Colorado River below Davis Dam unless required or authorized by these regulations.

(g) Nothing in this agreement shall be construed to require dangerously rapid changes in magnitudes of releases. Releases will be made in a manner consistent with requirements for protecting the dam, reservoir and appurtenances from major damages.

(h) Hoover Dam is but one of three major flood control reservoirs in the Lower Colorado River Basin. The Corps of Engineers operates Alamo Dam on the Bill Williams River and Painted Rock Dam on the Gila River. In that flows on these tributary streams contribute to the mainstem Colorado River, coordinated operation of all three reservoirs is essential to achieving flood control objectives. Hence temporary deviations from the Hoover Dam releases prescribed in this regulation may be necessary after consideration of the available storage, projected inflows, and required releases from these tributary reservoirs.

(i) The Bureau of Reclamation shall procure such current basic hydrologic data, and make such current calculations of permissible releases from Lake Mead as are required to accomplish the flood control objectives prescribed above.

(j) The Bureau of Reclamation shall keep the Los Angeles District Engineer, Corps of Engineers, Department of the Army, in charge of the locality, currently advised of reservoir releases, reservoir storage, and such other operating data as the District Engineer may request, and also of those basic operating criteria that effect the schedule of operation.

(k) The flood control regulations are subject to temporary modification by the Los Angeles District Engineer, Corps of Engineers, if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communications available. The action taken shall be confirmed in writing the same day to the office of the Regional Director and shall include justification for the action.

(l) The Regional Director may temporarily deviate from the flood control regulations in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of Hoover Dam and Lake Mead, or downstream dams, or the levee systems along the lower Colorado River. Such actions will be immediately reported by the fastest means of communication available. Actions shall be confirmed in writing the same day to the Los Angeles District Engineer, Corps of Engineers, and shall include justification for the action.

(m) The Bureau of Reclamation shall be responsible for providing adequate warnings to downstream interests when changes in release of stored floodwaters are made.

(n) Revisions to the flood control operation for Hoover Dam and Lake Mead may be developed as necessary by the parties of this agreement. Each such revision shall be effective on the date specified.

IN WITNESS WHEREOF, the parties hereto have caused this memorandum of agreement to be executed as of the day and date first above written.

Corps of Engineers

BY: _____
Brigadier General, USA
Division Engineer
South Pacific Division

Bureau of Reclamation

BY: _____
Regional Director
Lower Colorado Region

Table 1. Minimum flood control releases from Hoover Dam throughout the year.

CRITERIA	RELEASES
Water surface elevation between 1219.61 and 1221.40 feet (available storage between 1,500,000 and 1,218,000 acre-feet)	Make releases equal to inflow up to 28,000 cubic feet per second
Water surface elevation between 1221.40 and 1226.90 feet (available storage between 1,218,000 and 340,000 acre-feet)	Make outflow equal to inflow up to 40,000 cubic feet per second
Water surface elevation between 1226.90 feet to 1229.00 (available storage between 340,000 and 0 acre-feet	Make outflow equal to inflow up to 65,000 cubic feet per second
At water surface elevation 1229.00 (top of the flood control pool)	Maintain outflow equal to inflow

NOTE:

Water surface elevation (feet)	Water in storage (millions of acre-feet)	Available storage (millions of acre-feet)	Level
1205.40	23.708	3.669	Permanent spillway crest
1219.61	25.877	1.500	Minimum required flood control pool
1221.40	26.159	1.218	Top of spillway gates in raised position
1226.9	27.037	0.340	Spillway discharge equals 40,000 cubic feet per second with spillway gates in raised position
1229.00	27.377	0	Top of flood control pool
1232.00	---	0	Top of dam

EXHIBIT 1

FLOOD CONTROL ALGORITHM

The flood control algorithm is applicable during the period of 1 January through 31 July.

Definitions.

FI = the forecasted depleted inflow volume (in million acre-feet) to Lake Mead during the current month through 31 July, which will not be exceeded 19 times out of 20, and has been adjusted for effective storage space in selected upstream reservoirs excluding Lake Powell. FI is referred to as the maximum forecast.

SSM = current storage space (in million acre-feet) in Lake Mead below elevation 1229.0 feet.

SSP = current storage space (in million acre-feet) in Lake Powell below elevation 3700.0 feet.

RRM_N = the Hoover Dam hypothetical average release rate (in cubic feet per second at a specific step rate corresponding to the subscript N) through 31 July excluding the current month. Step values are as follows:

Release Step	Release Rate (cubic feet per second)
RRM_1	0
RRM_2	19,000
RRM_3	28,000
RRM_4	35,000
RRM_5	40,000
RRM_6	73,000

RCM = the Hoover Dam average release rate (in cubic feet per second) during the current month determined from solution of the volumetric equation given below.

FCR = the Hoover Dam average release rate (in cubic feet per second) required for flood control during the current month.

NCM = the number of days in the current month.

NRM = the number of remaining days from the present through 31 July excluding the current month.

BSM = the Lake Mead water loss (in million acre-feet) to bank storage during the current month through 31 July.

EVM = the Lake Mead water loss (in million acre-feet) due to evaporation at the lake surface during the current month through 31 July.

BSP = the Lake Powell net water loss (in million acre-feet) due bank storage during the current month through 31 July.

EVP = the Lake Powell net water loss (in million acre-feet) due to evaporation and precipitation during the current month through 31 July.

SNC = The Lake Mead net water withdrawal (in million acre-feet) due to consumptive use by the Southern Nevada Water Project during the current month through 31 July.

Detailed procedure and equations used to define the terms BSM, EVM, BSP and EVP are presented in Exhibit 2.

The volumetric equation applied to determine RCM is as follows:

$$FI = SSM + SSP - 1.5 + 1.9835 \times 10^{-6}((RCM \times NCM) + (RRM_N \times NRM)) + BSM + EVM + BSP + EVP + SNC$$

Solution of equality of the volumetric equation is iterative using progressively increasing step values of RRM_1 through RRM_6. RRM_N must be the smallest step value satisfying the requirement that RCM must be equal to or less than RRM_N.

The required Hoover Dam flood control release FCR during the current month is determined according to either condition a or b as follows:

(a) if RCM is greater than or equal to RRM_{N-1} then, FCR = RCM

or

(b) if RCM is less than RRM_{N-1} then, FCR = RRM_{N-1}

EXHIBIT 2

WATER LOSS EQUATIONS FOR

LAKES MEAD AND POWELL

July 1982

LAKE MEAD

$BSM = 0.065 (SSM - 1.5)$

$EVM = (NEM) (AAM \times 10^{-6})$

where:

BSM = the Lake Mead water loss (in million acre-feet) to bank storage during the current month through 31 July.

SSM = current storage space (in million acre-feet) in Lake Mead below elevation 1229.0 feet.

EVM = the Lake Mead water loss (in million acre-feet) due to evaporation at the lake surface during the current month through 31 July.

AAM = the average reservoir surface area (in acres) on Lake Mead from the current month through 31 July.

NEM = the average evaporation depth (in feet) for Lake Mead from the current month through 31 July as follows:

Month	Evaporation Rate (feet)
January	0.36
February	0.33
March	0.37
April	0.46
May	0.53
June	0.64
July	0.80

LAKE POWELL

BSP = 0.15 (SSP)

BSP = the Lake Powell water loss (in million acre-feet) to bank storage during the current month through 31 July.

SSP = current storage space (in million acre-feet) in Lake Powell below elevation 3700.0 feet.

$$EVP = (C_1E^4 + C_2E^3 + C_3E^2 + C_4E + C_5)\ (SM)$$

where:

EVP = the Lake Powell net water loss (in million acre-feet) due to evaporation and precipitation during the current month through 31 July.

E = the average water surface elevation of Lake Powell (in feet above mean sea level) from the current month through 31 July.

SM = a coefficient for the current month through 31 July as follows:

Period	Coefficient
January - July	0.536
February - July	0.486
March - July	0.439
April - July	0.380
May - July	0.313
June - July	0.222
July	0.118

Constants are as follows:

$C_1 = -1.06524 \times 10^{-12}$

$C_2 = 1.68872 \times 10^{-8}$

$C_3 = -9.51439 \times 10^{-5}$

$C_4 = 0.229605$

$C_5 = -2.0211176 \times 10^{2}$

The equations in Exhibit 2 may be revised based on prudent engineering analysis without requiring formal revision of the total field working agreement. Revision would be effective following written agreement between the Regional Director and the Division Engineer. All revised versions of Exhibit 2 shall be labeled indicating the date of revision before being effective.